1. Use the standard limit $\lim_{x \to 0} \frac{\sin x}{x} = 1$ to prove that

$$\lim_{h \to 0} \frac{\sin(x+h) - \sin(x)}{h} = \cos x,$$

thereby proving that $\frac{d}{dx} \sin x = \cos x$.

2. (a) Find an equation for the tangent to the curve $y = \frac{1}{x^2}$ at the point $(-1, 1)$. Find all intersection points of this tangent with the x- and y-axis. Graph both tangent and curve.
   (b) Find the linearization of $f(x) = x^{-2}$ at -1. See *Thomas' Calculus*, p. 202.
   (c) Let $a = -\frac{100}{99}$. With the linearization found in (b), approximate $f(a)$. Compare this to the real value of $f(a)$. Extra challenge: try to calculate the exact value of $f(a)$ without the use of a calculator.

3. Exercise 27-30 from *Thomas' Calculus* section 3.2 (p. 132). Match the functions with the derivatives. Also give possible formulas for $f_1(x)$, $f_2(x)$, $f_3(x)$ and $f_4(x)$.

4. (a) Establish a general product rule for $\frac{d}{dx}(uvw)$.

   (b) Find $\frac{dh}{dz}$ for

$$h = e^z(z-1)(z^2+1).$$

   Simplify your answer as much as possible.

   See *Thomas' Calculus*, page 140.

5. Find the derivative of y with respect to θ where

$$y = \ln\left(3\,\theta e^{\theta}\right).$$

6. Section 4.1, exercises 1–4 (p. 227): determine from the graph whether the function has any absolute extreme values on $[a, b]$. If that's the case, can we apply the Extreme Value Theorem? See *Thomas' Calculus* p. 223.
7. Which of the following assertions is correct? Motivate your answer.

   (a) $\lim_{x\to 3} \frac{x-3}{x^2-3} = \lim_{x\to 3} \frac{1}{2x} = \frac{1}{6}$ (L'Hôpital)

   (b) $\lim_{x\to 3} \frac{x-3}{x^2-3} = \frac{0}{6}$ (limit laws; quotient rule)

   (c) $\lim_{x\to 3} \frac{x-3}{x^2-3} = \lim_{x\to 3} \frac{1(x^2-3)-2x(x-3)}{(x^2-3)^2} = \frac{6}{36}$

   with quotient rule for differentiation

8. Define $f(x) = \begin{cases} x^2 \sin\left(\frac{1}{x}\right) & \text{if } x \neq 0, \\ 0 & \text{if } x = 0. \end{cases}$

   (a) Show that f is differentiable at 0, and calculate $f'(0)$.

   (b) Calculate $f'(x)$ for all $x \neq 0$.

   (c) Why is f' not continuous at 0?